Fertilization Technologies for Conservation Tillage Production Systems in California

FREP Contract # 00-056

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Introduction

Conservation tillage production row crop systems have a number of potential advantages that may be desirable to California producers including reduced production costs, maintenance of soil organic matter, and water conservation. Evaluation of this potential has been an increasingly important focus of the

University of California Division of Agriculture and Natural Resources Conservation Tillage Workgroup in recent years. To date, however, no systematic studies have been conducted in California to evaluate and understand the basis for optimal fertilization management strategies for reduced tillage systems. The selection of fertilizer rates, materials and application methods will likely require management decisions in conservation tillage systems that differ from those used in conventionally tilled systems. This project address two of FREP's key research and education priorities by developing new information on the fertilizer use efficiency of conservation tillage systems with and without cover crops compared to standard tillage systems with and without winter cover crops, and by providing this information in educational functions such as field demonstrations that are readily accessible to producers, consultants and resource managers.

Despite a 300% increase in conservation tillage (CT) production systems in the Midwest during the past decade, less than 0.3% of the acreage in California's Central Valley (CV) is currently farmed using CT practices. Preplant tillage operations typically account for 18 – 24% of overall production costs for annual crops grown in this region. An average of 9 to 11 tillage-related passes are routinely done during the fall-spring period to *prepare* the soil for summer cropping. These passes represent not only considerable energy, equipment and labor costs, but recent research indicates that tillage reduces soil organic matter (SOM) and emits considerable respirable dust as well. Because SOM is widely regarded as an important attribute of good soil quality and long-term productivity, interest has been growing over the last several years, in developing alternative production systems that reduce costs while at the same time improve the soil resource through greater carbon sequestration.

Recent pioneering studies by Reicosky and Lindstrom involving a variety of tillage methods indicate major gaseous losses of carbon (C) immediately following tillage, but point to the potential for reducing soil C loss and enhancing soil C management through the use of conservation tillage (CT) crop production systems. Though these practices have been developed over the past several decades primarily for erosion control in other parts of the US, recent concerns regarding the need to sustain soil quality and profitability have prompted an examination of CT practices in California.

Tillage in most annual cropping systems in California's Central Valley is typically done in a "broadcast" manner through a field, without deliberate regard to preserving dedicated crop growth or traffic zones. Studies by Carter over the last several decades, however, have confirmed the potential to eliminate deep tillage, decrease the number of soil preparation operations by as much as 60%, reduce unit production costs, lower soil impedance and maintain productivity in a number of CV cropping contexts using reduced, precision or zone tillage practices that limit traffic to permanent paths throughout a field thereby reducing soil compaction and preserving an optimum soil volume for root exploration and growth. No systematic studies have been conducted in California, however, that evaluate optimal fertilization strategies for these reduced tillage systems. Horwath *et al*. have shown that changes in fertilizer use efficiency occur when soils are managed for C sequestration in California. Additional work in other regions of the US has shown that the selection of nitrogen fertilizer rates, source and application methods requires management decisions in CT systems that differ from those used in conventionally tilled systems. Factors such as the type or quality of surface residue, residual soil fertility levels, soil temperatures, planting dates, crop variety and soil moisture determine optimal fertilization programs in CT systems. Soils in conservation tillage tend to be cooler, wetter, more firm and higher in organic matter near the surface than in conventional tillage. The likelihood of obtaining a yield response to starter fertilizer increased rapidly as tillage operations decrease.

In this project, we are adapting fertilization equipment that is currently used in CT systems in the midwest and southeast US and determining the fertilizer use efficiency using CT practices that we develop for San Joaquin and Sacramento Valley row crop systems. The hypothesis that we will test is that CT practices will promote an increase in soil organic matter (SOM), which in turn will lead to a greater nutrient cycling potential in the soil. This increased potential may then result in a lower fertilizer use efficiency, but a correspondingly lower rate of required fertilization.

Objectives

1. To evaluate the effectiveness of various fertilization practices in conservation tillage tomato, corn, and cotton production systems
2. To determine the fertilizer use efficiency in conservation tillage production systems transitioning to CT
3. To compare crop tissue nitrogen status in standard and conservation tillage production systems, and
4. To extend information developed by the project widely to Central Valley row crop producers via field days, equipment demonstrations and written project outcome summaries

Project Description

This project is being conducted in a 5 acre field at the Vegetable Crops and Weed Science Field Headquarters on the UC Davis campus and in an 8 acre field study at the UC West Side Research and Extension Center in Five Points, CA. A corn/tomato/corn/tomato rotation is being pursued at the UC Davis site, and a tomato/cotton/tomato/cotton rotation is used in Five Points. We report here on progress during 2001 and 2002 in the UC Davis study.

Four experimental treatments (standard tillage no cover crop, STNO, standard tillage with incorporated cover crop, STCC, conservation tillage no cover crop, CTNO, and conservation tillage with cover crop, CTCC) were established in the fall of 2000 in nine-bed (60”each) field plots that are replicated 4 times in a randomized complete block design. In 2001, a uniform field corn crop was produced across the entire field. Following corn harvest in September 2001, common vetch cover crops were seeded in each of the CC plots. Forty ^{15}N microplots (4.57m wide band 3m long) were then established during the 2001 – 2002 winter as indicated below.

STNO	**STCC**	**CTNO**	**CTCC**
Zero N	Zero N	Zero N	Zero N
Labeled fertilizer	Labeled fertilizer + vetch	Labeled fertilizer	Labeled fertilizer + vetch
	Labeled vetch + fertilizer		Labeled vetch + fertilizer

These microplots are being used to track the amount of ^{15}N-labeled fertilizer and vetch cover crop that is taken up by each of the main summer crops during the course of the study.

Results and Conclusions
Corn crop growth, percent post-harvest residue biomass and groundcover were quantified in October 2001 after soil tillage operations in the ST treatments were done. An average of about 2800 kg/ha of vetch dry matter was produced from November 2001 – April 2, 2002 in the CC plots.

Soil water content at the time of cover crop management in April 2002 was lower in each of the cover cropped (STCC and CTCC) systems at 0 – 15, 15 – 30, and 30 – 60 cm depths. The 2002 tomato crop was successfully transplanted into both the previous year’s corn residues and the corn residue/cover crop mulch. Fertilization was done using a rig fitted with 20” coulters ahead of standard fertilizer shanks. Yield data were collected in each plot using a machine harvester and weighing gondolas in August 2002. These data are currently being analyzed as are the ^{15}N uptake samples now being processed. It is premature to draw conclusions from this work at this time.